MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023 (TERM ID 2220)

ETN2126 – INFORMATION THEORY AND ERROR CODING

(TE)

7 JULY 2023
9:00 A.M – 11:00 A.M
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages including cover page with **4** Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) The probabilities for the first 4 symbols of a discrete memoryless source (DMS), S = {s_0, s_1, s_2, s_3, s_4} are $p_0 = 1/3$, $p_1 = ¼$, $p_2 = 1/5$ and $p_3 = 1/6$. The source emits symbols at a rate of one symbol every 1 millisecond.

(i) Calculate the entropy, H(S), of the given DMS.

[4 marks]

(ii) Calculate the information rate, R, of the source, S.

[3 marks]

(iii) Find the entropy of the extended source with degree, $n = 3$.

[3 marks]

(iv) Is the computed H(S) maximum? If not, find the maximum value for H(S).

[3 marks]

(b) Given a binary symmetric channel (BSC) with conditional probability of error, p.

(i) Draw the transitional probability diagram of this BSC.

[2 marks]

(ii) Two identical BSCs are then cascaded together. Find the overall channel matrix of the cascaded BSC channel.

[3 marks]

(iii) Draw the transition probability diagram of the cascaded BSC channel.

[4 marks]

(c) A Gaussian channel has a bandwidth, $B = 12$ kHz and two-sided noise power spectral density, $N_0/2 = 10^{-14}$ Watt/Hz. The signal power, P, at the receiver has to be maintained at a level of 0.2×10^{-3} Watts. Calculate the channel capacity, C.

[3 marks]

Continue...

Question 2

(a) Given a DMS, X = $\{x_0, x_1, x_2\}$ with its symbol probability distribution {0.3, 0.1, 0.6}.

(i) Define Shannon's source coding theorem.

[3 marks]

(ii) It is required that the codewords representing the above DMS have approximately fixed length. Design the Huffman code for the above DMS.

[9 marks]

(iii) Compute the efficiency of your Huffman code. How can you improve it?

[6 marks]

(b) Given that a source outputs a continuous stream of data. Part of the data stream sequence is shown below.

YBYYBBYYYBBYBB...

Using Lempel-Ziv coding, encode the data stream above with fixed length codewords of 4 bits. Let symbol Y be represented by bit 1 while symbol B is represented by bit 0.

[7 marks]

Continue...

Question 3

(a) In a (7, 4) linear block code, the generator matrix, **G** is given as

$$\mathbf{G} = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The output of this encoder is the codeword 1010010. Due to noise in the communication channel, an error pattern, **e** = 1001001 is induced when transmitting this codeword.

(i) Show the codeword that is obtained at the receiver.

[2 marks]

(ii) Using syndrome decoding, decode the received codeword to obtain the estimated message.

[7 marks]

(iii) Is the estimated message identical to the transmitted message? Justify your answer.

[3 marks]

(b) In the transmitter, the channel encoder implements a (15, 11) cyclic code with generator polynomial, $g(D) = 1 + D^2 + D^5$.

(i) Illustrate the circuit diagram of this channel encoder.

[5 marks]

(ii) The message, $m(D) = D^8 + D^{10}$ is to be encoded with the above cyclic code. Find the code polynomial of the message in systematic form using polynomial division.

[8 marks]

Continue...

Question 4

(a) The various states of a convolutional encoder together with its input and output relationship are shown in Table Q4.

Table Q4

Current Encoder State	Input Bit	Next Encoder State	Output Bits
00	0	01	00
00	1	10	01
01	0	11	11
01	1	00	10
10	0	01	00
10	1	00	11
11	0	10	10
11	1	11	01

(i) Draw the state diagram of the convolutional encoder.

[4 marks]

(ii) Using the state diagram, find the encoded sequence for the input bits 0 1 0 1 1 1.

[6 marks]

(iii) Draw the basic trellis diagram block for the convolutional encoder.

[4 marks]

(b) Trellis Coded Modulation (TCM) allows the receiver to obtain improved bit error rate performance as compared to a system without TCM while maintaining the same data rate and bandwidth.

(i) Explain the working principles of TCM.

[8 marks]

(ii) In a system without TCM, the 32-Quadrature Amplitude Modulation (32-QAM) is used to transmit data over a band-limited channel at a certain data rate. The TCM scheme is then utilized to improve the error performance of the original system. Determine the number of signaling points that is required at the TCM's constellation mapper for set partitioning.

[3 marks]

End of Paper